Feasibility Scoping Technical Memorandum

FROM: Katrina Higgins-Coltrain, U.S. Environmental Protection Agency, in association with EA Engineering, Science, and Technology, Inc., PBC (EA)

SUBJECT: Feasibility Scoping: Preliminary RAOs, ARARs, and Proposed Remedial Alternatives in Preparation of the Feasibility Study for Wilcox Oil Company Superfund Site, Bristow, Creek County, Oklahoma

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This technical memorandum (TM) proposes preliminary remedial action objectives (RAOs), draft applicable or relevant and appropriate requirements (ARARs), and identifies remedial technologies to be carried through the feasibility study evaluation. Information presented in the draft final Human Health Risk Assessment, draft final Ecological Risk Assessment, and the Draft Remedial Investigation Report was evaluated to develop the preliminary RAOs, ARARs, and technology screening process.

1.0 Development of Remedial Action Objectives (RAOs) based on the Finding of the RI and Risk Assessments

Based on the findings of the RI and risk assessments, the following preliminary RAOs are proposed.

<u>Soil</u>

- Prevent human exposure to the soils with concentrations of contaminants of concerns (COCs) exceeding the preliminary remediation goals (PRGs)
- Minimize migration of soil contaminants exceeding the preliminary remediation goals (PRGs)

It is noted that the monitoring well located on the Wilcox Process area has concentrations of contaminants above the maximum contaminant levels (MCLs). Additional information on ground water is needed prior to identifying appropriate RAOs or PRGs. Decisions related to ground water will be assessed at a future date after additional information is collected which may include the installation of additional wells, the collection of ground water samples, the collection of yield and flow data, the collection of data to support either active treatment or monitored natural attenuation or any other information or data necessary to assess ground water. This information will be used to assess the ground water conditions and fill data gaps such that a full evaluation of potential technologies can be completed.

2.0 Proposed Preliminary Soil Remediation Goals

Proposed soil PRGs were developed based on human health and ecological risk calculations. Attachments 1 and 2 provide summaries and detail calculations supporting the development of the ecological and human health risk soil PRGs, respectively.

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The following table shows the calculated PRGs for soil under residential and industrial/commercial land uses.

Soil

COC	Soil PRGs (mg/kg)	Land Use and Source
Benzo(a)pyrene	3	Residential & Industrial / commercial - human health risk based calculation
Copper	285	Ecological risk based calculation
Lead	200	Residential - human health risk based calculation
	400	Residential - human health risk based calculation
	800	Industrial / commercial - human health risk based calculation
Manganese	505	Ecological risk based calculation
Vanadium	66	Ecological risk based calculation
Zinc	120	Ecological risk based calculation
Note: Mg/kg = milligram per kilogram		

Application of the Soil PRGs would be based on the property use and expected future use. Further clarification on the zoning, current uses, and future uses as presented in a letter of intent from the property owners will be needed.

Property	Future Use proposal
North Tank Farm	Residential (northern portion)
North Tank Farm	Industrial/Commercial (southern portion)
Lorraine Process Area	Residential
Wilcox Process Area	Industrial/Commercial
East Tank Farm	Residential
Loading Dock Area	Industrial/Commercial

3.0 Preliminary Applicable Relevant and Appropriate Requirements (ARARs)

Table 1 presents the ARARs, which will be revised when the Soil PRGs and alternatives are finalized.

3.1 Technology Screening

Applicable technologies have been identified and screened using three criteria per the EPA guidance. The three criteria include effectiveness, implementability and cost. Table 2 presents the screening process for potential soil technologies.

Effectiveness is a measure of a technology's ability to reduce toxicity, volume or mobility of the contaminants to meet the site PRGs. Technologies that do not provide adequate protection of human health and environment or are not reliable (i.e., performance of the technology is not consistent to maintain a required treatment standard) are screened from further consideration.

Implementation is a measure of both technical and administrative feasibility of implementing a technology process. Aspects of implementability may include workability of the technology under site conditions, availability of special equipment and/or materials, requirement for skilled workers, and technology complexity. Technologies that are unworkable under the site conditions, or pose considerable challenges due to complicated technical process during the construction are eliminated from further consideration.

Cost is a measure of resources that are required in technology implementation. Cost evaluation at the technology screening phase is relative, typically presented as high, low, or medium compared to other technologies within the same technology type. The technologies with high cost but low protection of human health and environment are not considered for further evaluation.

The soil technologies retained for further evaluation include the following.

- No further action (NFA)
- Institutional controls (ICs)
- Excavation and offsite disposal
- Excavation and onsite disposal

3.2 Draft Soil Remedial Alternatives

The technologies retained from the screening process are assembled to develop a range of alternatives in order to provide some flexibility in selecting preferred alternatives. Following presents proposed alternatives for soil and groundwater.

Alternative 1: No Further Action (NFA)

Alternative 1 assumes no remedial action for soil to be conducted. It is considered as a baseline for comparison to other remedial alternatives. Under this alternative, the contaminated soil would be left in place and poses unacceptable risk to human health and ecological receptors.

Alternative 2: Excavation and Offsite Disposal

Alternative 2 includes excavation of soil exceeding the PRGs and disposal of the material offsite in a Resource Conservation and Recovery Act (RCRA) permitted and licensed landfill.

The main components of Alternative 2 include:

- Pre-excavation delineation of contaminated soil exceeding the PRGs
- Excavation of the contaminated soil
- Transportation to and disposal of the excavated material at an offsite disposal facility

- Backfill and restoration of excavated areas
- Implementation of institutional controls to restrict the land use, if needed

Alternative 3: Excavation and Disposal at Onsite Containment Repository

Alternative 3 includes excavating the contaminated soil, and consolidating the excavated soil into an onsite containment cell.

The main components of Alternative 3 include:

- Pre-excavation delineation of contaminated soil exceeding the PRGs
- Excavation of the contaminated soil
- Installation of an onsite containment cell, which may include:
    - Bottom liner system including (from bottom to up) an impermeable layer, a leachate collection layer and a protective layer
    - Contaminated and excavated soil
    - Capping including (from the bottom to up) an impermeable layer, a composite drainage net (for infiltration collection), and a soil cover with vegetation
- Backfill and restoration of the excavated areas
- Implementation of institutional controls to restrict the land use

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Tables

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Table 1. Potentially Applicable or Relevant and Appropriate Requirements

ARARs/TBCs	Citation or Reference	Requirements	Applicability
Chemical-Specific ARARs			
National Primary Drinking Water Standards	40 Code of Federal Regulations (CFR) Part 141	Establishes health-based standards (i.e., MCLs) for public drinking water.	Applicable for contaminants, which affect groundwater.
Clean Water Act	40 CFR Part 122	The National Pollutant Discharge Elimination System (NPDES) program is the national program for issuing, monitoring, and enforcing permits for direct discharges. 40 CFR Part 122 requires permits for the discharge of "pollutants" from any "point source" into "waters of the United States.".	Applicable potentially for alternatives of groundwater treatment system. Under the Superfund Program, an onsite discharge from a CERCLA site to surface water must meet the substantive NPDES requirements, but need not obtain an NPDES permit or comply with the administrative requirements of the permitting process.
Oklahoma Water Quality Standards	Oklahoma Administrative Code (OAC) 785:45	Establishes uses of waters of the state, criteria to maintain and protect such classifications and other standards or policies pertaining to the quality of such waters. These standards include groundwater protection requirements.	The requirements are applicable to the discharge of water from groundwater treatment, if a treatment system is included in remedial alternatives.
Implementation of Oklahoma Water Quality Standards	OAC 785:46	Establishes rules to implement the Oklahoma Water Quality Standards established under OAC 785:45.	May be applicable if remedy requires a surface water discharge.
Designation of Hazardous Substances, Determination of Reportable Quantities	40 CFR 302.4 – 302.5	This section provides tables on the following substances: a). Listed hazardous substances. The elements, compounds, and hazardous wastes appearing in Table 302.4 are designated as hazardous substances under Section 102(a) of CERCLA. b). Unlisted hazardous substances. A solid waste, as defined in 40 CFR 261.2, which is not excluded from regulation as a hazardous waste under 40 CFR 261.4(b), is a hazardous substance under Section 101(14) of CERCLA if it exhibits any of the characteristics identified in 40 CFR 261.20 through 261.24.	Applicable because hazardous substances might be in the contaminated soil, and groundwater. Waste encountered during the remediation of the contaminated media will be characterized to determine whether it is hazardous or nonhazardous.

ARARs/TBCs	Citation or Reference	Requirements	Applicability
Identification and Listing of Hazardous Waste	40 CFR 261	Identifies those waste subject to regulation as hazardous wastes.	The criteria and limitations used to identify wastes as being hazardous or nonhazardous are applicable to all wastes transported offsite and are relevant and appropriate to all alternatives at the site.
Oklahoma Air Pollution Control Rules	OAC 252:100	Establishes controls for specific hazardous air pollutants.	Applicable to discharge of fugitive dust during remedial actions.
Airborne Contamination Monitoring	American Conference of Governmental Industrial Hygienists – Threshold Limit Values (TLV)	Based on the development of a time-weighted average exposure to an airborne contaminant over an 8-hour workday or a 40-hour workweek, TLVs identify levels of airborne contaminants at which health risks may be associated.	Applicable during implementation of alternatives.
Airborne Contamination Monitoring	American Conference of Governmental Industrial Hygienists – Estimated Limit Values (ELV)	ELVs provide some indication of airborne contaminant levels at which adverse health effects could occur.	Applicable during implementation of alternatives.
OSHA Worker Protection	29 CFR 1910, 1926 and 1904	Establishes requirements for occupational health and safety applicable to workers engaged in hazardous waste site or CERCLA response actions	Applicable during implementation of alternatives.
Location-Specific ARARs/TBCs			
Floodplain Management	Executive Order 11988	Establishes federal policy and guidance for activities completed in floodplains	To be considered (TBC) since portions of the site are within a 100-year floodplain.
Protection of Wetlands	Executive Order No. 11990	Mandates that Federal agencies and potentially responsible parties avoid, to the extent possible, the adverse impacts associated with the destruction or loss of wetlands and avoid support of new construction in wetlands if a practicable alternative exists.	TBC during remedial actions since portions of the site are within or near wetlands.
Substantive requirements of Nationwide Permit #38 – Cleanup of Hazardous and Toxic Waste	33 CFR 330	Requires assessment of remedial actions to determine that impacts to wetlands cannot be avoided. Includes substantive performance standards. If mitigation is required a plan must be prepared and implemented. No pre-construction notification is required for CERCLA actions.	Applicable if remediation affects navigable waters or wetlands.

ARARs/TBCs	Citation or Reference	Requirements	Applicability
Migratory Bird Treaty Act	16 United States Code (USC) 703	Protects almost all species of native birds in the United States from unregulated taking.	Applicable if work is taking place in a migratory flyway.
Endangered Species Act of 1973	16 USC 1531-1548; 50 CFR Part 17 and 402	Requires remedial agency to consult with Fish and Wildlife Service if action may affect endangered species or critical habitat. Requires action to conserve endangered species within critical habitats upon which endangered species depend, includes consultation with Department of Interior.	No documentation is found to show endangered species are present at the site, however, it is TBC to confirm that during the soil remediation.
Permits and Enforcement	CERCLA 121 (e)	This section of CERCLA states that no "federal, state, or local permit" shall be required for any portion of a CERCLA remedial action that is conducted on the site of the facility being remediated. This includes exemption from the Resource Conservation and Recovery Act (RCRA) permitting process. Note that the substantive requirements of the regulations must still be met (e.g., construction stormwater must be managed using best management practices [BMPs]).	Applicable to the remedial action at the site.
The Native American Graves Protection And Repatriation Act	25 USC Section 3001 et seq and its regulations Title 43 CFR Part 10	Protects Native American graves from desecration through the removal and trafficking of human remains and cultural items including funerary and sacred objects.	Substantive requirements applicable if Native American burials or cultural items are identified within area to be disturbed.
National Historic Preservation Act	16 USC 470 et seq; 36 CFR Part 800	Provides for the protection of sites with historic places and structures	Substantive requirements applicable if eligible resources are identified within area to be disturbed.
Archeological Resources Protection Act of 1979	16 USC Sections 47000-47011; 43 CFR Part 7	Prohibits removal of or damage to archaeological resources unless by permit or exception	Substantive requirements applicable if eligible resources are identified within area to be disturbed.
American Indian Religious Freedom Act	42 USC Section 1996 et seq.	Protects religious, ceremonial, and burial sites, and the free practice of religions by Native American groups.	Substantive requirements applicable if Native American sacred sites are identified within area to be disturbed.

ARARs/TBCs	Citation or Reference	Requirements	Applicability
ACTION-SPECIFIC ARARs/TBCs			
Water Quality Standards	40 CFR 131	States are granted enforcement jurisdiction over direct discharges and may adopt reasonable standards to protect or enhance the uses and qualities of surface water bodies in the state.	Applicable to direct discharge of treatment system effluent or other process waters.
Hazardous Substances	40 CFR A Parts 116.3 and 116.4	Establishes reporting requirements for certain discharges or reportable quantities of hazardous substances. Creates no substantive clean up requirement.	May be applicable to the site based on the chosen remedial alternative, and if discharges of reportable quantities of hazardous substances occur during implementation of the remedy.
Underground Injection Control	40 CFR. Part 144 OAC 252:650 and 652	Injection of liquids associated with remedial alternatives is subject to Federal and State Underground Injection Code (UIC) requirements.	Applicable for groundwater treatment alternatives involving injections. Operators of Class V injection wells must notify the UIC Director and submit inventory information about the well. Class V injection wells cannot allow the movement of fluid into underground sources of drinking water that may cause the violation of primary drinking water standards or health based standards. Class V injection wells must be closed in accordance with 40 CFR. 144.82(b)
RCRA	40 CFR. Part 262 Subsection B, & Part 263, 49 CFR 100 through 199	Establishes responsibilities for transporters of hazardous waste in handling, transportation, and management of the waste. Sets requirements for manifesting, recordkeeping, packing, labeling, and emergency response action in case of a spill.	Applicable depending on waste classification and if it is transported offsite for disposal.

ARARs/TBCs	Citation or Reference	Requirements	Applicability
RCRA Land Disposal	40 CFR Part 268	Land Disposal Restrictions (LDRs): Establishes restrictions on land disposal unless treatment standards are met or a "no migration exemption" is granted. LDRs establish prohibitions, treatment standards, and storage limitations before disposal for certain wastes as set forth in Subparts C and D. Treatment standards are expressed either as concentration based performance standards or as specific treatment methods. Wastes must be treated according to the appropriate standard before wastes or the treatment residuals of wastes may be disposed in or on the land. The Universal Treatment Standards establish a concentration limit for 300 regulated constituents in soil regardless of waste type.	Applicable for disposal of hazardous wastes
Transportation	49 CFR. Part 171	Hazardous materials that may be transported off site cannot be transported in interstate and intrastate commerce, except in accordance with the requirements of 49 CFR Part 171, Subpart C.	Applicable for any offsite transportation of hazardous waste will comply with these regulations, which contain packaging, placarding, labeling, and other shipping requirements.
National Primary and Secondary Ambient Air Quality Standards	40 CFR 50 and Clean Air Act Part A, 109	Establishes ambient air quality standards.	Applicable to alternatives that potentially generate emissions, i.e., stabilization, *in situ* injection, and waste removal.
Requirements for Preparation, Adoption, and Submittal of Implementation Plans	40 CFR 51	Requires excavation activities be controlled to minimize fugitive dust emissions.	Applicable to some alternatives that will generate fugitive dust emissions from excavation of contaminated soil.
Clear Water Act	Title II, Section 208(b)	The proposed action must be consistent with regional water quality management plans as developed under Section 208 of Clean Water Act.	Substantive requirements adopted by the state pursuant to Section 208 of the Clean Water Act would be applicable to direct discharge of treatment system effluent or other discharges to surface water.
Clear Water Act	Title III, Section 304	Establishes water quality criteria for specific pollutants for the protection of human health and for the protection of aquatic life. These federal water quality criteria are nonenforceable guidelines used by the state to set water quality standards for surface water.	Water quality criteria may be relevant and appropriate to groundwater or other discharges to surface water.

ARARs/TBCs	Citation or Reference	Requirements	Applicability
Effluent Guidelines and Standards	40 CFR 400 series	Wastewaters from certain processes need to meet certain pretreatment requirements and concentrations before being discharged to a publicly owned treatment plant (POTW) or discharged through a permitted outfall. These standards include: - 40 CFR 437 – Centralized Waste Treatment Point Source Category - 40 CFR 445 – Landfills Point Source Category	Applicable, if a waste liquid is produced and treated during remediation prior to discharge or relevant and appropriate if groundwater is treated and discharged.
Guidelines for Land Disposal of Solid Wastes	40 CFR 241	Offsite solid waste land-disposal units must meet the federal guidelines for the land disposal of solid wastes.	Applicability depends on waste classification for wastes generated from the remediation.
Criteria for Classification of Solid Waste Disposal Facility and Practices	Subtitle D, 40 CFR 257	Sets standards for land disposal facilities for nonhazardous waste.	Applicable to transport and disposal of any nonhazardous waste offsite.
Hazardous Waste Management; Standards Applicable to Generators of Hazardous Waste; and Standards Applicable to Transporters of Hazardous Waste	Subtitle C 40 CFR 260, 262, and 263. OAC 252:205 – Oklahoma Hazardous Waste Management Rules	Regulates the generation, transport, storage, treatment, and disposal of hazardous wastes generated in the course of a remedial action. Regulates the construction, design, monitoring, operation, and closure of hazardous waste facilities.	Requirements under these regulations may be relevant and appropriate to storage of wastes or treatment system residuals.
Solid Waste Management	OAC 252:515	Implements the Oklahoma Solid Waste Management Act (OSWMA), which provides rules for the transportation, handling, storage, and/or disposal of solid waste regulated by the OSWMA.	The requirements are applicable to the transportation, handling, storage, and/or disposal of any solid wastes generated during remedial action.
General Water Quality Standards	OAC 252:611	Nonpoint source Pollution controls	Substantive requirements are relevant and appropriate to construction activities.
Well Driller and Pump Installer Licensing	OAC 785:35	Establishes requirements for well drilling and plugging.	Potentially applicable if installation or plugging and abandonment of groundwater monitoring wells or boreholes takes place.

ARARs/TBCs	Citation or Reference	Requirements	Applicability

Notes:
ARAR = Applicable Relevant and Appropriate Requirement
BMP = best management practice
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act
CFR = Code of Federal Regulations
ELV = Estimated Limit Values
LDR = Land Disposal Restrictions
MCL = Maximum Concentration Level
NPDES = The National Pollutant Discharge Elimination System
OAC = Oklahoma Administrative Cod
OSWMA = Oklahoma Solid Waste Management Act
POTW = Publicly owned treatment plant
RCRA = Resource Conservation and Recovery Act
TBC = To be considered
TLV = Threshold Limit Values
UIC = Underground Injection Code
USC = United States Code

Table 2. General Response Actions and Potential Applicable Technologies - Soil

General Response Action	Remedial Technology Type	Process Option	Description	Effectiveness	Implementability	Cost	Potential for Retain for Further Evaluation
No Further Action	None	None	No further action to address contaminated soil and sediment.	Will not address the remedial objectives.	None	None	Yes as baseline for evaluation process
Institutional Controls	Access and Use Restrictions	Land Use Controls	Land use restriction (i.e., deed notice or restrictive covenant) is issued for properties located in the contaminated areas to restrict the land use to either residential or industrial / commercial only pending on EPA decision.	Will prevent direct exposure to the contaminants; therefore it will address relevant remedial objectives.	Implementable	Low	Yes
Containment	Consolidation and Capping	Clay Cap, Synthetic Membrane, or Chemical Sealant or Stabilizer	A cap is installed to cover the contaminated area to prevent direct exposure to the contamination. Different materials can be used for the cap and typical materials include clay, synthetic membranes, and chemical sealants or stabilizers. Contaminated soil can be consolidated in one area and capped.	Will prevent direct contact and exposure to the contaminated soil , although it does not remove the source of the contamination. It will address the relevant remedial objectives.	Implementable with commercially available equipment; potential worker and community exposure to dust; administrative controls will be required.	Medium	Not as a stand-alone technology and it is included in containment cell option
Removal	Excavation and Disposal	Excavation and Onsite Disposal	Contaminated soil is excavated and placed in a containment cell which may consist of a bottom liner and a cap. Bottom liner may consist of, from bottom to top a impermeable liner, leach collection layer, a protection layer overlain by excavated contaminated soil. A cap may consist of an impermeable layer, an infiltration collection layer, and soil cover and vegetation.	Will prevent direct contact and exposure to the contaminated soil , and contain the contaminated materials in a cell. It will address the relevant remedial objectives.	Implementable with commercially available equipment. Potential worker and community exposure to dust during the construction, therefore dust controls will be required. A deed notice is required to control the future land use and protect the integrity of the cell.	Medium, but the quantity of the contaminated soil is relatively low, so building a small containment cell might not be cost effective because of a low ratio of waste quantity versus cell construction materials.	Yes
		Excavation and Offsite Disposal	Contaminated soil are excavated and transported to a permitted offsite facility for disposal.	Will remove the contaminated soil from the site. It will address the relevant remedial objectives.	Implementable	Medium	Yes
Treatment	*Ex situ* Physical, Chemical Treatment	Excavation and Chemical Oxidation	Oxidizing agents (Fenton's reagent, permanganate, ozone, and hypochlorites) are added into the excavated soil to promote abiotic destruction of contaminants. Treated soil is placed back to the excavations	Chemical oxidation will destroy the contaminants to become less toxic; however some metals (chromium) may become mobile once being oxidized and may impact the groundwater.	Implementable, and a bench scale testing is required to determine oxidant dosage.	High, can be cost prohibitive if the soil contains high organic matter.	No, due to potential mobilization of metals to the groundwater
		Excavation and Soil Mixing and Stabilization/Solidification	Reagents are mixed with excavated soil by a mechanical mixing device to trap, treat, or immobilize contaminants. Treated soil is placed back to the excavations and covered by clean soil and vegetation. Reagents may include cement, bentonite, activated carbon.	Will stabilize and reduce contaminants' migration. However the treated soil is required to be protected from excavation, drilling, and other earthmoving activities. Institutional controls are required to protect the treated soil.	Implementable with commercially available equipment; treatability study is required to determine reagent dosing; may take longer time to treat; potential worker exposure is present during construction, especially during materials handling.	High	No, due to high cost
		Excavation and Soil Washing	Contaminants in soil are desorbed by using a solution of leaching agent, surfactant, pH adjustment, or chelating agent to help remove the contaminants and fine materials on which the contaminants absorbed.	Will address the remedial objectives by removing the contaminants from the soil .	Complex process and produces a large quantity of process water that requires treatment. Acid reagent may be used to remove lead from soil, which increase the health and safety concern during the implementation.	High	No, due to complex implementation and cost
		Excavation and Thermal Treatment	Heat is applied to the excavated soil to increase the volatility of the contaminants. An off-gas treatment will be used to treat the volatilized PAHs and lead. *Ex situ* thermal treatment technologies include hot gas decontamination, incineration, thermal desorption, and vitrification, which is a high-temperature treatment to immobilize contaminants by incorporating them in the vitrified end product.	Will destroy the contaminants (i.e., lead and PAHs), so it will address the remedial objectives.	Not readily implementable, treatability studies required; significant materials handling; specialized equipment and operators; extended construction/ treatment period (6-7 months); viscous nature may require pre-treatment; potential community opposition; potential combination with other technology for residual management; onsite management of residuals will need institutional controls.	High	No, due to complex implementation and cost
		Landfarming	Landfarming is used for the biological treatment of contaminated soil. It consists of spreading excavated contaminated soil either directly on the ground or on a membrane with an upper protective layer to prevent contaminants from migrating to the soil underneath and to the groundwater. Mixing or tilling of the contaminated soil is normally required to blend nutrients/amendments, and distribute moisture to promote biodegradation of the contaminants. Periodical watering is also required to provide optimal condition for microbial activities.	Landfarming is typically applicable to nonvolatile and semi- volatile compounds. Biodegradation of PAHs becomes more difficult as the number of aromatic rings increase. Therefore landfarming typically is not considered to be effective for treating PAHs that contain more than four rings, i.e., benzo(a)pyrene. It is not certain with currently available data if landfarming will be effective for treating lead in soil.	Implementable, however it may take a long period of time depending on biodegradation process in the soil.	Low	No due to ineffectiveness for PAHs with more aromatic rings and lead
	In Situ Treatment	*In Situ* Stabilization/Solidification	Contaminated soil is mixing in place with reagents to form a solid with certain strength and low permeability to immobilize contaminants or reduce contaminants to a less toxic form. Reagents may include Portland cement, lime, fly ash, organoclay, activated carbon, and bentonite.	May stabilize both organic and metal contaminants. Will need institutional controls to protect the treated soil from excavation, drilling, and other earthmoving activities. Institutional controls are required to protect the treated soil. However, the soil contamination is relatively shallow therefore, *in situ* stabilization is not cost effective.	Implementable with commercially available equipment; treatability study is required to determine reagent dosing; may take longer time to treat.	High	No due to high cost
		Phytoremediation	Plants are used to remove, transfer, stabilize and destroy contaminants in soil. Biodegradation takes place in the soil immediately surrounding plant roots; plant roots can also accumulate and stabilize contaminants in the soil.	Effectiveness of phytoremediation can be seasonal; in some cases it is limited to shallow soil. It is uncertain if the contaminant concentrations are tolerant or toxic to plants.	Implementable	Low	No, due to uncertainty of effectiveness

NOTE:

COC = Contaminant of concern
ISTD = *In Situ* Thermal Desorption
CO = *In situ* chemical oxidation

RH = Electrical resistive heating
SVE = Soil vapor extraction

MNA = Monitored natural attenuation
Polycyclic aromatic hydrocarbon

Attachment 1

Development of Preliminary Remediation Goals Based on Ecological Risk Assessment for the Wilcox Oil Company Superfund Site

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23 May 2020

TECHNICAL MEMORANDUM

TO: Katrina Higgins-Coltrain, EPA Region 6

FROM: Melissa Beauchemin, Ecological Risk Assessor

SUBJECT: Development of Preliminary Remediation Goals for the Wilcox Oil Company Superfund Site, Bristow, Creek County, Oklahoma

The following memorandum discusses the derivation of Preliminary Remediation Goals (PRGs) for the Wilcox Oil Company Superfund Site.

1. SLERA RESULTS

A SLERA was conducted in September 2019 following Steps 1 and 2 of EPA's Ecological Risk Assessment Guidance (EPA 1997, 1998). The SLERA used conservative assumptions, including conservative toxicity reference values (TRVs) and input parameters for food web models (e.g., 100% site use, 100% earthworm ingestion, etc.). These steps also assumed maximum exposure scenarios (e.g., maximum ingestion rates and exposure point concentrations [EPCs]). Modifications were conducted as part of Step 3 of the ERA process that used more realistic EPCs (i.e., 95UCL) and incorporated lowest effect level TRVs. Despite the modifications, the SLERA identified potential risks (based on HQs greater than 1) for the following receptors from the following COPECs, per Table 8-1 in the SLERA:

Area	Receptor	COPEC
Wilcox and Lorraine Process Area	Plants	Chromium Copper Lead Vanadium Zinc
	Soil Invertebrates	Chromium Chromium VI Copper Mercury Zinc Isopropylbenzene Xylenes
	Insectivorous Mammals	Lead
	Insectivorous Birds	Lead Vanadium
	Herbivorous Birds	Copper Lead

Area	Receptor	COPEC
Tank Farm and Loading Dock Area	Plants	Chromium Manganese Vanadium
	Soil Invertebrates	Chromium Isopropylbenzene
	Insectivorous Birds	Lead Vanadium
Ponds	Aquatic Organisms	Cadmium Lead Benzo(a)pyrene
Streams	Benthic Invertebrates	Total PAHs
	Aquatic Organisms	Manganese

2. SLERA REFINEMENT – LOWER TROPHIC LEVEL ORGANISMS

The following section discusses COPECs for lower trophic level receptors, specifically plants and soil invertebrates that had SLERA HQs greater than 1.

2.1 Total PAHs

Concentrations of Total PAHs in sediment, when compared to the probable effects level (PEL) of 16.8 mg/kg (MacDonald et al 1996) instead of threshold effects level (TEL) of 1.68 mg/kg used in the SLERA, indicates no potential risk to benthic organisms from total PAHs in stream sediments.

2.2 Isopropylbenzene and Xylenes

Isopropylbenzene and xylenes were sporadically detected in soils at the site. No direct toxicological studies have been published related to these compounds, and the Region 4 soil screening values (EPA 2018) used to identify COPECs were generated from theoretical structure-activity relations (SAR) using the EPA ECOSAR program to generate water values which may result in toxicity to aquatic organisms. The assumption was made that soil invertebrates are equivalent to sediment invertebrates so that partitioning of the chemicals to organic carbon (assuming 1% organic carbon) was used to generate the risk screening values of 0.04 mg/kg and 0.1 mg/kg for isopropylbenzene and total xylenes respectively. Because of infrequent detection, volatile nature of the chemicals, absence of direct toxicological studies, and the unsubstantiated theoretical nature of the soil screening values, it is not expected that either COPECs would result in unacceptable risk to populations of soil invertebrates, and no PRGs have been derived.

2.3 Metals

Where potential risks exist for multiple endpoints (e.g., lower and upper-trophic level organisms), PRGs for metals are unlikely to be based upon lower-trophic level receptors such as plant and soil invertebrates, but rather to upper-trophic level wildlife instead. There is a paucity of toxicological data in the literature for soil invertebrates and plants and soil screening numbers are generally developed to be extremely conservative. The purpose of screening values such as

EcoSSLs is to provide a conservative prediction of potential risk so that areas that may present potential risk are not overlooked. This is different than soil clean-up levels or PRGs which are designed for risk management and consider more realistic and site-specific exposure and toxicity scenarios.

Sporadic elevations of concentrations of metals in soil would not necessarily be toxic to entire populations of plants and/or invertebrates. In fact, many plants are tolerant of high concentrations of metals and will accumulate significant concentrations of metals without demonstrating any adverse effects. Because of plants' ability to accumulate concentrations of metals, they are often used for phytoremediation.

Efroymson et al. (1997a) notes that four plant studies showed no adverse effects to plants with lead concentrations in soil of at least 100 mg/kg and even up to 500 mg/kg of lead. In several instances, effects were not observed until lead concentrations in soil were 500 to 1,000 mg/kg. A recent phytotoxicity study by Cheyns et al. (2012) revealed no impacts to tomato and barley plants until lead concentrations in soil reached 1,600 mg/kg for tomatoes and 1,900 mg/kg for barley, at which point growth impacts were observed.

Copper and manganese are essential nutrients in plants and important in oxidation, photosynthesis, and protein and carbohydrate metabolism. Copper deficiency is demonstrated by wilting leaves, melanism, and white twisted tips (EPA 2007a). Manganese deficient plants exhibit decreased growth, interveinal chlorosis, necrotic spots on leaves, and browning of roots (EPA 2007b).

Zinc EcoSSLs have been derived for terrestrial plants and soil invertebrates. The EcoSSL of 160 mg/kg for terrestrial plants was derived based on the geometric mean of the maximum acceptable toxicant concentrations (MATC) for three species under different test conditions. The EcoSSL of 120 mg/kg for soil invertebrates is the geometric mean of the effect concentration for 10 percent of the test population (EC_{10}) and MATC values for at least three test species under different test conditions (EPA 2007d). These values are considered PRGs for the site. However, it should also be noted there is little vegetation present in the process areas where the highest concentrations are located.

Due to the lack of adequate toxicity studies, there are no EcoSSLs for chromium or vanadium for soil invertebrates or plants. More current lower trophic level toxicological literature associated with chromium and zinc were searched for but none were located. There are also no EcoSSL values for mercury. Efroymson et al. (1997a) cautions that their plant "benchmarks are to serve primarily for contaminant screening."

Availability of contaminants for uptake by earthworms is controlled by soil characteristics such as grain size, pH, organic carbon content, and moisture content (Efroymson et al. 1997b). Efroymson et al. 1997b cautions that their soil invertebrate "benchmarks are appropriate for contaminant screening purposes only."

Zinc PRGs for plants and invertebrates were determined as discussed above. Due to the lack of plant and soil invertebrate toxicity data for chromium, vanadium, and mercury, PRGs for these metals will be based upon potential risks to upper-trophic level receptors (i.e., birds and mammals) which may consume plants and invertebrates. Cleanup levels based on these wildlife species are likely to be protective of populations of lower trophic organisms as well. As such, the food web models were revised for copper, lead, and vanadium in the next section.

3. FOOD WEB MODEL REFINEMENT – UPPER TROPHIC LEVEL ORGANISMS

As part of the SLERA refinement, food web models can be modified to reflect more realistic and site-specific input parameters. For instance, in the SLERA, to be conservative, the robin was assumed to ingest 100% earthworms; however, robins actually eat a mixed diet that includes both fruits and insects. EPA (1993) indicates that in the central U.S. robins ingest approximately 50% plants and 50% invertebrates. The revised food web models for lead and vanadium assume a diet of 50% plants and 50% invertebrates. In addition, robins are migratory and will likely reside in the area for only eight months of the year. A seasonal use factor of 0.67 was used for the revised food web models.

The SLERA also assumed the shrew has a soil ingestion rate of 13% based on Sample and Suter (1994). More recent estimates of soil ingestion for the shrew based on EPA's EcoSSL documents (EPA 2007c) indicate that their soil ingestion rate is only approximately 3%. The soil ingestion rate of 3% was used in the revised food web model. Furthermore, EPA (1993) indicates that shrews also ingest some plant tissue (approximately 17% of their diet) as well as mammals (approximately 5% of their diet). As such, the dietary composition for the shrew was updated to 78% invertebrates, 17% plants, and 5% mammals in the revised food web model.

3.1 Bioaccumulation

Over the past decade, much research has focused on the bioavailability of metals, especially in terms of risk. Only the bioavailable component (species) of metals is capable of uptake by a receptor organism, and therefore, only that portion is capable of eliciting adverse effects. The bioavailability of metals in soil is influenced by the species (forms) present, particle size, organic carbon content, and whether minerals have been encapsulated or coated by other mineral phases. These factors can all influence metal bioavailability, often reducing it to less than 100% (Kaufman et al. 2007).

Bioaccumulation factors (BAFs) for plants and earthworms used in the revised food web models have been updated in the EcoSSL guidance documents (EPA 2007c) as shown below:

COPEC	Plant BAF	Invertebrate BAF
Copper	$\ln(C_{plant}) = (0.669+0.394*\ln(C_{soil}))$	$C_{worm} = C_{soil} \times 0.515$
Lead	$\ln(C_{plant})=(-1.328+0.561*\ln(C_{soil}))$	$\ln(C_{worm}) = (-0.218+0.807*\ln(C_{soil}))$
Vanadium	$C_{plant} = C_{soil} \times 0.00485$	$C_{worm} = C_{soil} \times 0.042$

3.2 Bioaccessibility

In order to pose a risk to an organism, ingested contaminants must be "bioaccessible," meaning they must be able to enter the gastrointestinal tract of the organism and be absorbed into the bloodstream. The quantity of bioaccessible metal available to an organism can be analyzed in the laboratory via *in vitro* methods. Using a synthetic gastric solution consisting of various acids, laboratories are able to distinguish between organic (bioavailable) and inorganic (non-bioavailable) forms of metals, by the quantity of metal extracted or "digested" from the sample. Suedel et al. (2006) showed that the majority of lead in soil at a former refinery was in its inorganic form, with bioaccessibility percentages ranging from 8 to 78%. Incorporating the bioavailability/bioaccessibility factor into the food web models for the ecological risk assessment substantially reduced risk estimates (Suedel et al. 2006).

Kaufman et al. (2007) conducted bioaccessibility models for mammals (eastern cottontail and short-tailed shrew) and birds (American robin) to investigate the proportion of lead mobilized into the digestive juices (i.e., the bioaccessible fraction) from soil, earthworms, and vegetation collected at a rifle and pistol range in Canada. Total lead concentrations averaged 5,044 mg/kg in surface soil, 727 mg/kg in earthworm tissue, and 2,945 mg/kg in unwashed vegetation. For mammalian gastric models, the bioaccessible fraction of lead in soils was 66%, in earthworm tissue it was 77%, and in unwashed vegetation the bioaccessible fraction was 50%. For the avian gastric model, the bioaccessible fraction of lead in soil was 53%, and in earthworm tissue it was 73%.

Kaufman et al. (2007) demonstrated that the incorporation of soil and food web intermediate bioaccessibility data into standard ecological risk calculations results in lower risk estimates for all receptors. Hazard quotients did not exceed 1 for the American robin until soil lead concentrations reached 1,000 mg/kg. The inclusion of bioaccessibility information during ecological risk assessment provided a more realistic estimate of contaminant exposure and is a valuable tool for use in management of contaminated sites. Using only total metals concentrations can lead to an overestimation of risk and the potential for unwarranted and costly site remediation (Kaufman et al. 2007).

As such, the food web models were modified to incorporate a bioaccessibility factor for lead as follows:

Receptor	Media Ingested	Bioaccessibility Factor (B)
Robin	Soil	53%
	Earthworms	73%
	Plants	100%[a]
Shrew	Soil	66%
	Earthworms	77%
	Plants	50%
Sparrow	Soil	53%
	Plants	100%[a]

a. No value identified by Kaufman et al. 2007 so plants assumed to contain lead that is 100% bioaccessibile.

3.3 TRV Refinement

For the development of avian TRVs, the EcoSSL documents for lead (EPA 2005a) and vanadium (EPA 2005b) present a large range of NOAEL and LOAEL TRVs, many of which are based on chickens. Because chickens are bred for agriculture, they have unnaturally high growth and reproduction rates. Furthermore, chickens do not ingest earthworms and should not be used as a surrogate for insectivorous birds. Many of the studies use gavage methods as the route of exposure in the study. This forced feeding causes animals to have much higher ingestion rates than normal when foraging on their own.

The toxicity dataset used in the EcoSSL documents to identify TRVs includes studies with medium- or low-level confidence. Studies ranked with a Data Evaluation Score of 80 to 100 have a higher degree of confidence than studies ranked in the 60s (low confidence) or 70s (medium confidence).

For copper, the published EcoSSL TRVs of 4.05 mg/kg-day and 12.1 mg/kg-day were used without modification (EPA 2007a).

3.3.1 Lead

EPA's Eco SSL Document for Lead (EPA 2005a) provides a range of avian TRVs that spans up to six orders of magnitude. NOAEL TRVs based on survival, growth, or reproduction range from 0.194 to 196 mg/kg and LOAEL TRVs range from 0.11 to 625 mg/kg. EPA recommends a NOAEL TRV of 1.63 mg/kg-day and a LOAEL of 3.26 mg/kg from the corresponding study. The NOAEL TRV is based on a study (Edens and Garlich 1983) that used chickens which are an inappropriate receptor because, as mentioned above, they are domestic animals with abnormally high reproduction (i.e., egg-laying) and growth rates. The study was based in the laboratory, not in the field, and therefore is not representative of natural conditions. The study was only four weeks long, which is not a sufficiently long study to identify chronic toxicity values.

Sample et al. (1996) calculated a NOAEL TRV of 3.85 mg/kg-day from a study by Pattee (1984). This study evaluated eggshell thickness in American kestrel (wild bird) which is more representative of ecological receptors in their natural habitat with natural reproduction rates. The study was conducted over a period of six months. Because the study was conducted for more than 10 weeks and during a critical lifestage (eggs), the study is considered chronic. EPA (2005) ranked the Pattee (1984) study with the highest evaluation score of all the lead-bird studies (value of 90). The Edens and Garlich (1983) study was ranked only at 79. The NOAEL from the same study as calculated by EPA is 12 mg/kg-day (2005). This discrepancy is likely the result of differing estimated ingestion rates because none was provided in the study. However, EPA (2005) calculated a geometric mean value of all the NOAELs for avian reproduction and growth to be 10.9 mg/kg-day, which is similar to the NOAEL calculated by EPA (2005) from the Pattee (1984) study (12 mg/kg-day). As such the recommended avian NOAEL for lead is 3.85 mg/kg. Because there was no LOAEL associated with the study, an uncertainty factor of 10 is applied to estimate the corresponding LOAEL of 38.5 mg/kg. These values were incorporated into the back-calculated food web model to identify a protective lead soil concentration for birds.

3.3.2 Vanadium

For vanadium, the avian TRVs selected in the EcoSSL document (EPA 2005b) are extremely low – the NOAEL is 0.344 and the LOAEL is 0.688 mg/kg. The EcoSSL dataset has NOAELs for growth, reproduction, and survival that range from 0.244 to 98.7 mg/kg. LOAELs range from 0.319 to 14.8 mg/kg. Because many of the studies use chickens and do not have data scores with a high level of confidence, EA sought to calculate a more reasonable TRV. Studies with endpoints for survival, growth, and reproduction with data evaluation scores less than 80 were eliminated. Studies that did not have a bounded NOAEL and LOAEL were also eliminated. This left a total of 26 studies. Although all based on chickens, data evaluation scores ranged from 81 to 90 indicating a high degree of confidence in the results of the studies. Resulting NOAELs ranged from 0.244 to 6.37 mg/kg and LOAELs ranged from 0.413 to 14.8 mg/kg. The geometric mean of the NOAELs is 1.24 mg/kg and the geometric mean of the LOAELs is 2.5 mg/kg. These values were incorporated into the back-calculated food web model to identify a protective vanadium soil concentration for birds.

3.4 Results

Using the modified input parameters identified above, the food web models were set up to back-calculate a protective soil concentration for copper, lead, and vanadium (i.e., equivalent to a HQ of 1). This was done using the following equation:

$$PRG = C_{soil} = \frac{TRV \times BW \times HQ}{SUF \times \{(IR_{soil} \times B_{soil}) + \sum_{i=1}^{n}(IR_{food} \times BAF \times Fx_{diet} \times B_{food})\}}$$

Where:

PRG	=	preliminary remediation goal (mg/kg)
C_{soil}	=	concentration in soil (mg/kg)
TRV	=	toxicity reference value (mg/kg-bw/day)
BW	=	body weight (kg)
HQ	=	hazard quotient (unitless)
SUF	=	site use factor (unitless)
IR_{soil}	=	ingestion rate of soil (kg/day)
IR_{food}	=	ingestion rate of food (kg/day)
BAF	=	bioaccumulation factor (unitless)
B	=	bioaccessibility factor for soil and food, respectively (percent)
Fx_{diet}	=	fraction of prey (i) in diet
$\sum$	=	sum of ingestion for all prey

After the exposure parameters and input values were entered into an Excel spreadsheet and the calculation was considered complete, PRGs were developed using the "What if, Goal seek" data function in Excel. This function sets the cell for the HQ to 1 while changing the soil concentration in the equation. This is conducted for both the NOAEL and LOAEL TRV. Geometric mean-based PRGs are a reasonable balance between no effect and lowest effect toxicity levels (EPA 1999). Therefore, the geometric mean of the two values is selected as the PRG. Attached Tables 1 through 3 present the food web models for robin (insectivorous bird), shrew (insectivorous mammal), and sparrow (herbivorous bird), respectively. The following table summarizes the PRGs:

COPEC	Back-Calculated PRG (mg/kg)	Receptor
Copper	**285**	Herbivorous Bird
Lead	**204**	Insectivorous Mammal
	441	Insectivorous Bird
	907	Herbivorous Bird
Vanadium	**66**	Insectivorous Bird

3.5 Background

Background values are also considered because CERCLA does not cleanup to levels below background (EPA 2002). Two background datasets are available, including a site-specific background upper prediction limit (UPL) that was calculated as part of the SLERA as well as regional (Oklahoma) soil background values from the EcoSSL documents (EPA 2007c). Background values for these constituents are lower than the PRGs, as noted below:

COPEC	UPL (mg/kg)	Regional OK Background (mg/kg)	Final PRG (mg/kg)	Basis
Copper	3.24	15.9	285	Herbivorous bird
Lead	9.19	17.6	204	Insectivorous Mammal
Manganese	505	465	505	UPL
Vanadium	11.17	50	66	Insectivorous Bird
Zinc	14.2	50	120	Soil Invertebrates

Note: The EcoSSL for manganese that is protective of plants is 220 mg/kg which is lower than either background concentration.

3.6 Aquatic Organisms

Potential risks to aquatic organisms in the ponds and streams from elevated concentrations of constituents in the water column are likely to be reduced following removal of contaminated soil in the upland. Because sediment in these areas is not impacted and there is no need for sediment removal, water quality monitoring may be necessary to ensure that water column concentrations decrease following soil removal activities.

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Tables

Tables

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Preliminary Remediation Goals for American robin

LOAEL-based values

	Body Weight (kg)	SUF	Bioaccessibility Plants	Bioaccessibility Inverts	Bioaccessibility Soil	Dietary Composition (%) Plants	Dietary Composition (%) Inverts	Tissue Concentrations (mg/kg) Plants	Tissue Concentrations (mg/kg) Inverts	Food Ingestion Rate (kg/day dw)	Soil Ingestion Rate	Dietary Dose (mg/kg-day)	TRV (mg/kg-d) LOAEL	PRG (mg/kg) LOAEL	HQ
Lead	0.077	0.67	1.00	0.73	0.53	50%	50%	17	314	0.0171	0.0018	38.49	38.5	1627.55	1.00
Vanadium	0.077	0.67	1	1	1	50%	50%	0.452	4	0.0171	0.0018	2.50	2.5	93.09	1.00

NOAEL-based values

	Body Weight (kg)	SUF	Bioaccessibility Plants	Bioaccessibility Inverts	Bioaccessibility Soil	Dietary Composition (%) Plants	Dietary Composition (%) Inverts	Tissue Concentrations (mg/kg) Plants	Tissue Concentrations (mg/kg) Inverts	Food Ingestion Rate (kg/day dw)	Soil Ingestion Rate	Dietary Dose (mg/kg-day)	TRV (mg/kg-d) NOAEL	PRG (mg/kg) NOAEL	HQ
Lead	0.077	0.67	1	0.73	0.53	50%	50%	4	38	0.0171	0.0018	3.85	3.85	119.59	1.00
Vanadium	0.077	0.67	1	1	1	50%	50%	0.22	2	0.0171	0.0018	1.24	1.24	46.17	1.00

Lead	Exposure Parameters			
Lead	Body Weight	0.077 kg		
Vanadium	BAFworm	ln(dry worm conc, mg/kg) = (-0.218+0.807*ln(soil conc))		
Vanadium	BAFplant	ln(dry plant conc, mg/kg) = (-1.328+0.561*ln(soil conc))		
Copper	BAFworm	4.20E-02	EcoSSL	
Copper	BAFplant	4.85E-03	EcoSSL	
	BAFworm	0.515	EcoSSL	
	BAFplant	ln(dry plant conc, mg/kg) = (0.669+0.394*ln(soil conc))	EcoSSL	
			EcoSSL	
			EcoSSL	

	Geomeans	Bkgd
lead	**441**	18
vanadium	**66**	50

Bird TRVs	NOAEL	LOAEL	Ref
Lead	3.85	38.5	Sample et al. 1996
copper	4.05	12.1	EcoSSL TRVs
Vanadium	1.24	2.5	self-derived TRVs

Mammal TRVs	NOAEL	LOAEL	
Lead	4.7	8.9	EcoSSL

Food Ingestion Rate	0.22	kg dry wt./kg-day	Converted assuming 75% prey moisture (USACHPPM 2004)
Food Ingestion Rate	0.89	kg wet wt./kg-day	EPA 1993
Incidental Soil Ingest	10.50%	% of total mass of diet	Value based on woodcock (Sample and Suter 1994)

Food ingestion	0.0171325	dry weight	kg/d
Food ingestion	0.06853	wet weight	kg/d
soil ingestion	0.0017989	dry	kg/d

SOUTHERN SHORT-TAILED SHREW

Body Weight	0.017213	kg		Plants	17%
Food Ingestion Rate	0.16	kg dry wt./kg-day		Inverts	78%
Food Ingestion Rate	0.62	kg wet wt./kg-day		Mammals	5%
Incidental Soil Ingestion Rate	3.00%	% of total mass of diet			

FIR	0.00275	kg/d
SIR	8E-05	kg/d

Preliminary Remediation Goals for Shrew

LOAEL-based values

	Body Weight (kg)	SUF	Bioaccessibility			Dietary Composition (%)			Tissue Concentrations (mg/kg)			Food Ingestion Rate (kg/day dw)	Soil Ingestion Rate (kg/day dw)	Dietary Dose (mg/kg-day)	TRV (mg/kg-d)	PRG (mg/kg)	HQ
			Inverts	Soil	Plants	Inverts	Plants	Mammals	Inverts	Plants	Mammals				LOAEL	LOAEL	
Lead	0.017213	1	0.77	0.66	0.50	78%	17%	5%	81	7	13	0.0028	0.0001	8.90	8.9	301.79	1.00

NOAEL-based values

	Body Weight (kg)	SUF	Bioaccessibility			Dietary Composition (%)			Tissue Concentrations (mg/kg)			Food Ingestion Rate (kg/day dw)	Soil Ingestion Rate (kg/day dw)	Dietary Dose (mg/kg-day)	TRV (mg/kg-d)	PRG (mg/kg)	HQ
			Inverts	Soil	Plants	Inverts	Plants	Mammals	Inverts	Plants	Mammals				NOAEL	NOAEL	
Lead	0.017213	1	0.77	0.66	0.5	78%	17%	5%	43	4	10	0.0028	0.0001	4.70	4.70	138.33	1.00

Geomean **204**

SONG SPARROW

Body Weight	0.032	kg	Sherman and Wasser 2010; average weight of song sparrow
Food Ingestion Rate	0.2141	kg dry wt./kg-day	Calculated using allometric equation for birds from Nagy 2001
Food Ingestion Rate	0.8566	kg wet wt./kg-day	Converted assuming 75% prey moisture (USACHPPM 2004)
Incidental Soil Ingestion Rate	9%	% of total mass of diet	Beyer et al 1994, value for turkey

FIR	0.0068512	kg/d
SIR	0.0006166	kg/d

Preliminary Remediation Goals for Song Sparrow

LOAEL-based values

	Body Weight (kg)	SUF	Bioaccessibility Plants	Bioaccessibility Soil	Dietary Composition (%) Plants	Concentrations (mg/kg) Plants	Food Ingestion Rate (kg/day dw)	Soil Ingestion Rate (kg/day	Dietary Dose (mg/kg-day)	TRV (mg/kg-d) LOAEL	PRG (mg/kg) LOAEL	HQ
Lead	0.032	1	1.0	0.53	100%	25	0.0069	0.0006	38.50	38.5	3250.83	1.00
Copper	0.032	1	1	0.53	100%	25	0.0069	0.0006	12.10	12.1	657.24	1.00

NOAEL-based values

	Body Weight (kg)	SUF	Bioaccessibility Plants	Bioaccessibility Soil	Dietary Composition (%) Plants	Concentrations (mg/kg) Plants	Food Ingestion Rate (kg/day dw)	Soil Ingestion Rate (kg/day	Dietary Dose (mg/kg-day)	TRV (mg/kg-d) NOAEL	PRG (mg/kg) NOAEL	HQ
Lead	0.032	1	1	0.53	100%	6	0.0069	0.0006	3.85	3.85	253.00	1.00
Copper	0.032	1	1	0.53	100%	13	0.0069	0.0006	4.05	4.05	123.54	1.00

	Geomean
Lead	907
Copper	285

Attachment 2

Development of Preliminary Remediation Goals Based on Human Health Risk Assessment for the Wilcox Oil Company Superfund Site

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23 May 2020 with revision by EPA on June 10, 2020

TECHNICAL MEMORANDUM

TO: Katrina Higgins-Coltrain, EPA Region 6

FROM: Cynthia Cheatwood, Human Health Risk Assessor / EA Engineering, Science, & Technology, Inc., PBC (EA)

SUBJECT: Development of Human Health Risk Based Preliminary Remediation Goals for the Wilcox Oil Company Superfund Site, Bristow, Creek County, Oklahoma

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This technical memorandum discusses the derivation of Preliminary Remediation Goals (PRGs) based on the human health risk assessment (HHRA) for the Wilcox Oil Company Superfund Site.

1. HUMAN HEALTH RISK MANAGEMENT DECISIONS

As noted in the HHRA and RI report, a number of potential source areas were present within the Site. These potential source areas include the skimming and cracking plant, re-distillation battery, stills, cooling ponds, Lead Additive Area, approximately 10 buildings housing refinery operations, storage tanks, and other related refinery structures historically located on the Lorraine and Wilcox Process Areas. Other potential source areas include approximately 80 bulk storage tanks of various sizes historically located at the Lorraine and Wilcox Process Areas, as well as the East and North Tank Farms. Surficial waste material was also identified in the Loading Dock Area.

Crude oil, fuel oil, gas oil, distillate, kerosene, naphtha, and benzene (petroleum ether), acids, and other refined products were reportedly stored on the property (EA 2016c). Site data suggest that periodic releases of crude oil, sludge, and refined product occurred in these areas during operations. These releases may have been discharged to surface and subsurface soil, and subsequently migrated to groundwater, surface water, and sediment. VOCs may have also migrated into the vadose zone as soil gas.

As a result of the varied sources and source areas, the HHRA evaluated a wide range of contaminants of potential concern (COPCs) in site media for each of the five exposure areas. Risk results for most of the COPCs fall within EPA's risk management range. Many of these additional COPCs are suspected to be ubiquitous regional contaminants related to historical activities and/or background concentrations rather than site-specific contaminants. This section provides: (1) a basis of understanding regarding carcinogenic and non-carcinogenic risks and EPA's risk management range, (2) a discussion of chemicals that fall above EPA's acceptable risk range, and (3) an evaluation of chemicals within EPA's risk management range based on spatial extent, magnitude of exceedance, and fate and transport considerations in order to determine an appropriate path forward within the context of risk management.

1.1 BASIS OF UNDERSTANDING

Human health risks are evaluated by carcinogenic and non-carcinogenic risks as discussed in the subsections below. Additionally, potential human health concerns associated with lead in soil were evaluated using blood-lead modeling.

1.1.1 Carcinogenic Risk

For carcinogens, risks are expressed as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to the level of the carcinogen at the site. A carcinogenic risk of 10^{-6} indicates that an individual experiencing the reasonable maximum exposure estimate for the site has a 1 in 1,000,000 chance of developing cancer as a result of site-related exposure. This is referred to as an excess incremental lifetime cancer risk because it would be in addition to the risks of cancer individuals face from other causes. The chance of an individual developing cancer from all other causes has been estimated to be as high as 40 percent (Howlader et al., 2015).

Because the cancer slope factor (used to calculate excess lifetime carcinogenic risk) is the statistical 95th percent upper-bound confidence limit on the dose-response slope, this method provides a conservative, upper-bound estimate of risk. It should be noted that the interpretation of the significance of the cancer risk estimate is based on the appropriate public policy. EPA in the NCP (40 Code of Federal Regulation Part 300) (1990a) states that:

> *"...For known or suspected carcinogens, acceptable exposure levels are generally concentration levels that represent an excess upper bound lifetime cancer risk to an individual of between 10^{-4} and 10^{-6}."*

This risk range represents EPA's generally acceptable risk range for site-related exposures, or a 1 in 10,000 to 1 in 1,000,000 chance, respectively, of an individual developing cancer. Carcinogenic risks that are below the lower end of the acceptable risk range (i.e., 10^{-6}) are considered *de minimis* and require no action. Carcinogenic risks within the risk management range (i.e., between 10^{-4} and 10^{-6}) are subject to a risk management decision. Generally, only carcinogenic risks above the upper end of the acceptable risk range (i.e., 10^{-4}) warrant additional consideration. However, the upper end of the cancer risk range is not a discrete line and "specific risk estimate around 10(-4) may be considered acceptable if justified based on site-specific conditions, including any remaining uncertainties on the nature and extent of contamination and associated risks (EPA 1991c)". Additionally, the EPA notes, "A risk manager may also decide that a lower level of risk to human health is unacceptable and that remedial action is warranted where, for example, there are uncertainties in the risk assessment results (EPA 1991c)."

1.1.2 Non-carcinogenic Risk

For non-carcinogens (systemic toxicants), potential effects are evaluated by comparing an exposure level over a specified time period (e.g., exposure duration) with a reference dose or reference concentration derived for a similar exposure period. A reference dose or reference concentration represents a level to which an individual may be exposed and not expected to cause any harmful effect. A HQ (ratio of average daily intake level to acceptable daily intake level) of less than 1.0 indicates that a receptor's dose of a single contaminant is less than the reference dose. As a result, there will be no concern that potential adverse systemic health effects will be observed in the exposed populations. However, if the sum of several HQs exceeds 1.0, and the COPC affect the same target organ, there may be concern that potential adverse systemic health effects will be observed in the exposed populations. In general, the greater the value of the HQ above 1.0, the greater the level of concern. However, the HQ does not represent a statistical probability that an adverse health effect will occur.

For the consideration of exposures to more than one chemical causing systemic toxicity via several different pathways, the individual HQs are summed to provide an overall HI. If the HI is less than 1.0, then no adverse health effects are likely to be associated with exposures at the site. However, if the total HI is greater than 1.0, separate endpoint-specific HIs may be calculated based on toxic endpoint of concern or target organ (e.g., HQs for neurotoxins are summed separately from HQs for renal toxins). If an endpoint-specific HI is greater than 1.0, there is reason for concern about potential health effects for that endpoint. Similar to carcinogenic risks, uncertainties associated with the risk assessment may not warrant action for noncancer hazards that are greater than 1.0.

1.1.3 Lead Modeling

Potential health concerns associated with lead exposure relates the effect in terms of the amount of lead in blood associated with an observed effect. For this HHRA, the amount of lead in blood associated with an observed effect was set to a reference value based on the 97.5th percentile of the NHANES-generated blood-lead level in children 1-5 years old (CDC 2012) which equates to 5 µg/dL. Therefore, this blood-lead level is used to identify potential concerns for children with elevated blood-lead levels. Additionally, blood-lead levels of 8 µg/dL and 10 µg/dL were evaluated. To achieve a specific level of protectiveness, the EPA has established a limit that a typical (or hypothetical) child would have an estimated risk of no more than 5 percent exceeding the reference blood-lead level.

1.1.4 Media and Chemicals With Carcinogenic Risks Above 10^{-4} , Non-carcinogenic Hazards Above a Hazard Index of 1.0, or Blood-Lead Level Exceedance

The HHRA revealed carcinogenic risks above 10^{-4}, noncarcinogenic hazards above 1.0, and/or blood-lead levels above a level of concern for soil within the Loading Dock Area, Wilcox Process Area, and Lorraine Process Area and shallow groundwater within the Wilcox Process Area. Media and chemicals that resulted in potential risk concerns are discussed below.

1.1.4.1 Soil

<u>Lead</u>

Surface soil within the Lorraine Process Area and Wilcox Process revealed greater than 5% of the child population exceeded all reference blood-lead levels evaluated in the IEUBK. A range of reference blood-lead levels were evaluated: 5 µg /dL, 8 µg /dL, and 10 µg /dL. This reveals lead is a potential concern for resident children in surface soil within the Lorraine Process Area and the Wilcox Process Area. For the adult lead model, only the 5 µg/dL reference blood-lead level had greater than 5% of the population exceeding in the Lorraine and Wilcox Process Areas. Additionally, the Lead Additive Area within the Wilcox Process Area has surface soil that contains high levels of leachable lead down to a depth of approximately 2 ft bgs. This source area is being addressed under the site's Source Control ROD (EPA 2018b) and was not evaluated in this HHRA. This reveals lead is a potential concern across these areas and is identified as a COPC for further consideration.

Metals (Cobalt, Copper, Iron)

The HHRA revealed cobalt, copper, and iron, with noncarcinogenic hazards greater than 1 for the Loading Dock Area (cobalt) and the Wilcox Process Area (cobalt, copper, iron) under the resident scenario. The exceedance of the noncarcinogenic hazard of 1 was due to the ingestion of homegrown produce and ingestion of beef exposure pathways. As noted, these pathways are modeled from surface soil concentrations. The models used to estimate the concentration of these metals in produce and beef have a high degree of uncertainty and are likely to overestimate potential concentrations. For cobalt, the background UPL is 11.1 mg/kg. The 95UCL within the Loading Dock Area (15.2 mg/kg) is only slightly higher than the background UPL, and the Wilcox Process Area 95UCL (3.87 mg/kg) is lower than the background UPL. This reveals that cobalt is not a site concern. For copper within the Wilcox Process Area, the 95UCL is highly influenced by the maximum detected concentration of 7,490 mg/kg at WPA-SB-28-0.5. The sample collected at 2 ft bgs at WPA-SB-28 revealed a copper concentration of 8.8 mg/kg. Also, this maximum detected concentration is 60 times higher than the next highest detection of 124 mg/kg at WPA-SB-48. For iron within the Wilcox Process Area, the maximum detected concentration of 47,500 mg/kg at WPA-SB-27-0.5 slightly exceeds the background UPL of 14,700 mg/kg. Additionally, the maximum detected concentration does not exceed the full residential soil RSL of 55,000 mg/kg. As a result of the uncertainty associated with the homegrown produce and beef ingestion exposure routes and overall chemical concentrations, cobalt, copper, and iron are not considered COPCs for the site.

Residential Yards

The assessment of the residential yards found potential concerns for exposure to surface soil. Carcinogenic risks were equal to the upper end of the EPA's acceptable cancer risk range, and non-carcinogenic hazards were above 1. Cadmium and cobalt were the COPCs with non-carcinogenic hazards above 1, and benzo(a)pyrene and arsenic are the primary contributors to carcinogenic risks. It is noted that the assessment of the residential yards used the maximum detected concentration. Additionally, risk concerns identified for soil also include the ingestion of homegrown produce and beef. As noted previously, these exposure routes are modeled on conservative parameters and likely overestimate risks.

The maximum detected concentration of cobalt in surface soil was 61.2 mg/kg (sample location WO-021-005-06-51) and a 95%UCLM of 3.69 mg/kg (Table 3.16). The 95%UCLM of cobalt is below the background UTL of 11.1 mg/kg (Table 2.16). This reveals the overall distribution of cobalt concentrations across the residential yards is consistent with background concentrations. Additionally, the maximum detected concentration of cobalt at residential location WO-021 is six times higher than the next detect of 10.9 mg/kg. The 95UCL for cobalt at location WO-021 15.0 mg/kg, which would result in a noncarcinogenic hazard less than 1 for cobalt. Therefore, cobalt is not retained as a COPC for the residential yards.

The background cadmium (average or 95UCL) could not be calculated because it was detected in only one background sample while all others were non-detect. The non-carcinogenic hazard of 2 is a result of direct contact with soil and ingestion of homegrown produce. The ingestion of homegrown produce is a modeled exposure pathway with high uncertainty. Additionally, these risk results are based upon the maximum detected concentration of 80.2 at WO-008-001. The next highest detection of cadmium at WO-008 was 2.2 mg/kg. Additionally, the overall 95%UCLM of cadmium was 0.23 mg/kg and the arithmetic mean was 6.07 mg/kg of all residential yards combined (Table 3.16). Both of these are below the EPA RSL of 71 mg/kg. This reveals that cadmium concentrations are not a concern across the residential yards and is not retained as a COPC.

Arsenic and benzo(a)pyrene were the primary contributors to carcinogenic risks of $1x10^{-4}$ within the residential yards. Similar to cadmium, the 95UCL for arsenic (3.29 mg/kg) and benzo(a)pyrene (0.148 mg/kg) are an order of magnitude lower than the maximum detected concentration used in the risk calculations (Table 3.16). This reveals the overall distribution of arsenic and benzo(a)pyrene in the residential yards is not a concern.

1.1.5 Media and Chemicals Subject to a Risk Management Decision: Carcinogenic Risks Between 10^{-6} and 10^{-4}

Potential exposures to surface water and sediment at the site were within the EPA acceptable cancer risk range and noncarcinogenic hazards were below the level of concern. Therefore, these media are not expected to pose human health concerns. Carcinogenic risks for all receptors exposure to soil were also within the EPA acceptable risk range.

It is noted that the HHRA evaluated potential human health concerns based the entire exposure area. However, the exposure areas are larger than area that are typically evaluated for residential yards. To further evaluate the surface soil medium of concern and evaluate potential concerns for smaller exposure areas (i.e., potential residential yards), sample results were reviewed to determine if areas of high concentration are present within the five soil exposure areas. Areas of high concentration were determined as concentrations that exceed the residential soil RSL by two orders of magnitude (i.e., 100 times). The only chemical that exceeded this criterion was benzo(a)pyrene within the Wilcox Process Area, the Lorraine Process Area, and East Tank Farm. The maximum detected concentrations of benzo(a)pyrene in surface soil (WPA-SB-20-2.0 at 31 mg/kg; LOR-TP-09-0.5 at 38.9 mg/kg; and ETF-SB-02-0.5 at 12 mg/kg) and subsurface soil (WPA-SB-20-6.0 at 24 mg/kg) exceeded the residential soil RSL by greater than two orders of magnitude. Additionally, benzo(a)pyrene was detected within WPA-SB-18-2.0 at 23 mg/kg. The highest detections of benzo(a)pyrene were primarily within the Wilcox Process Area, except for the one detection within the Lorraine Process Area and one location in the East Tank Farm. The maximum detected concentration of benzo(a)pyrene in surface soil (ETF-SB-02-0.5 at 12 mg/kg) within the East Tank Farm exceeded the residential soil RSL by two orders of magnitude; however, this location was cleaned up as a result of a removal action completed in 2017. Therefore, benzo(a)pyrene should be retained as a COPC for the site.

2. DEVELOPMENT OF PRGS

Risk results from the HHRA were reviewed to determine PRGs for the site. The site-specific PRGs are chemical limits calculated upon toxicity values and site-specific exposure conditions evaluated in the HHRA (EA 2020). As presented in the HHRA, the site was divided into five exposure areas for evaluation due to the sites overall size and configuration. The HHRA determined potential health concerns for receptors with exposures to lead in soil (Lorraine Process Area and Wilcox Process Area) and exposures to shallow groundwater (Wilcox Process Area). For shallow groundwater, potential unacceptable risks were determined for the resident, construction worker, and commercial worker exposure.

Additionally, soil sample results were reviewed to determine if areas of high concentration are present within the five soil exposure areas. Areas of high concentration were determined as concentrations that exceed the residential soil Regional Screening Level (RSL) by two orders of magnitude (i.e., 100 times). The only chemical that exceeded this criterion was benzo(a)pyrene. Therefore, benzo(a)pyrene was also identified as a COPC.

PRGs were determined for each of the chemicals identified as COPCs. PRGs were developed for chemicals with cancer risks greater than 10^{-6} and target organ specific Hazard Index (HI) greater than 1. Tables 1 through 2
present a summary of the PRGs calculated for the site COPCs. Calculations for the determination of PRGs are provided in Attachment 1. The PRGs are for cancer risk levels of 10^{-6}, 10^{-5}, and 10^{-4} or a noncancer hazard of 0.1 and 1. The following equation was used to calculate site-specific PRGs:

For carcinogens:

$$Site\ Specific\ PRG = \frac{EPC}{Risk} \times TR$$

Where,

PRG	=	Preliminary remediation goal
TR	=	Target carcinogenic risk level (i.e., 10^{-6}, 10^{-5}, 10^{-4})
Risk	=	Chemical-specific cumulative carcinogenic risk calculated in HHRA
EPC	=	Chemical-specific exposure point concentration presented in HHRA

For non-carcinogens:

$$Site\ Specific\ PRG = \frac{EPC}{HQ} \times THQ$$

Where,

PRG	=	Preliminary remediation goal
THQ	=	Target hazard quotient (i.e., 1, 0.1)
HQ	=	Chemical-specific total hazard quotient shown in HHRA
EPC	=	Chemical-specific exposure point concentration presented in HHRA.

3. SELECTION OF SOIL PRGS

A brief discussion of the risk-based PRGs is presented below.

Lead is classified a probable human carcinogen. However, EPA has not published a slope factor (SF) or inhalation unit risk (IUR) for quantifying carcinogenic risks. Blood lead levels are the indicator of excess lead exposure in humans. In the HHRA, modeled blood level results are compared to the established threshold of no more than 5 percent of the population having a blood-lead of 5, 8, and 10 micrograms (µg) lead per deciliter (dL) or greater. Blood-lead levels were evaluated for residents using the EPA's Integrated Exposure Uptake Biokinetic Model (IEUBK) Lead Model and for workers using the EPA's Recommendations of the Technical Review Workgroup (TRW) for Lead, An Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil. Land use within the five exposure areas at the site vary from residential to commercial/industrial. Zoning does not exist for the area the site is located. As a result, acceptable lead concentrations in soil may vary within an exposure area. To simply this difference in land use across the exposure area, lead PRGs were determined based upon the blood-lead levels of 5, 8, and 10 µg lead/dL of blood. The IEUBK model was used to determine the appropriate PRGs for the various blood-lead levels. It is noted that the IEUBK model does not provide a printout of the PRG determination. For the worker, the EPA Adult Lead Model was used to determine the appropriate PRGs for the various blood-lead levels. Outputs from this model are provided in Attachment 1. The final selection of the appropriate PRG will depend upon identified land use and remedial feasibility.

Benzo(a)pyrene was identified as a site COPC in the HHRA even though carcinogenic risks were within the EPA acceptable cancer risk range. The HHRA evaluated potential human health concerns based the entire exposure area. However, the exposure areas are larger than typical areas that are evaluated as residential yards. To further evaluate the surface soil medium of concern and evaluate potential concerns for smaller exposure areas (i.e., potential residential yards), sample results were reviewed to determine if areas of high concentration are present within the five soil exposure areas. Based upon this review, it was determined that localized levels of benzo(a)pyrene within the Wilcox Process Area and East Tank Farm may present carcinogenic risks greater than the EPA acceptable cancer risk range. For benzo(a)pyrene, the highest concentrations in soil were found just north of the lead additive area in the Wilcox Process Area (sample locations WPA-SB-09, WPA-SB-18 and WPA-SB-20).

Tables 1 and 2 present the summary of soil COPC PRGs for the resident and commercial/industrial worker in soil.

4. REFERENCES

EA Engineering, Science, and Technology, Inc. PBC. 2020. *Final Human Health Risk Assessment, Revision 02, Remedial Investigation / Feasibility Study, Wilcox Oil Company Superfund Site, Bristow, Creek County, Oklahoma*. April

Oklahoma Department of Environmental Quality (ODEQ). 2020. *Letter to Katrina Higgins-Coltrain, EPA, From: Todd Downham, ODEQ, Re: Groundwater Use, Wilcox Oil Company Superfund Site, Bristow, Creek County, Oklahoma*. 19 May 2020.

Tables

Tables

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TABLE 1
RISK-BASED SITE-SPECIFIC PRELIMINARY REMEDIATION GOALS FOR CARCINOGENIC AND NON-CARCINOGENIC RISKS IN SOIL
RESIDENT ADULT AND CHILD
WILCOX OIL COMPANY SUPERFUND SITE
BRISTOW, CREEK COUNTY, OKLAHOMA

Contaminant of Concern	PRG[1] for HI = 1.0 (mg/kg)	PRG[1] for HI = 0.1 (mg/kg)	Site-Specific PRG for Carcinogenic Risk 10^{-6} (mg/kg)	Site-Specific PRG for Carcinogenic Risk 10^{-5} (mg/kg)	Site-Specific PRG for Carcinogenic Risk 10^{-4} (mg/kg)	Background UPL (mg/kg)	Maximum Concentration[2] (mg/kg)
Resident Adult and Child[3]							
Benzo(a)pyrene	NA	NA	0.12	1.2	11.5	NA	31.0
Contaminant of Concern	**PRG for HI = 1.0 (mg/kg)**	**PRG for HI = 0.1 (mg/kg)**	**Site-Specific PRG for 5 µg/dL Blood-Lead Level[3] (mg/kg)**	**Site-Specific PRG for 8 µg/dL Blood-Lead Level[3] (mg/kg)**	**Site-Specific PRG for 10 µg/dL Blood-Lead Level[3] (mg/kg)**	**Background UPL (mg/kg)**	**Maximum Concentration[2] (mg/kg)**
Resident Child							
Lead	NA	NA	200	300	400	9.19	20,800

1) Non carcinogenic hazard was below a level of 1, so noncancer endpoint is not evaluated.
2) Maximum concentration is for the entire Wilcox Oil Superfund Site.
3) Carcinogenic risks for the resident adult and child are combined to represent a lifetime, incremental carcinogenic risk
4) PRGs for lead are rounded to one significant figure to remain consistent with EPA lead policy.

EPC - Exposure Point Concentration
mg/kg - milligrams per kilogram
NA - Not Applicable
HI - Hazard Index
PRG - Preliminary Remediation Goal
RME - Reasonable Maximum Exposure

TABLE 2
RISK-BASED SITE-SPECIFIC PRELIMINARY REMEDIATION GOALS FOR CARCINOGENIC AND NON-CARCINOGENIC RISKS IN SOIL
COMMERCIAL/INDUSTRIAL WORKER
WILCOX OIL COMPANY SUPERFUND SITE
BRISTOW, CREEK COUNTY, OKLAHOMA

Contaminant of Concern	PRG[1] for HI = 1.0 (mg/kg)	PRG[1] for HI = 0.1 (mg/kg)	Site-Specific PRG for Carcinogenic Risk 10^{-6} (mg/kg)	Site-Specific PRG for Carcinogenic Risk 10^{-5} (mg/kg)	Site-Specific PRG for Carcinogenic Risk 10^{-4} (mg/kg)	Background UPL (mg/kg)	Maximum Concentration[2] (mg/kg)
Worker							
Benzo(a)pyrene	NA	NA	3.0	30	300	NA	31.0
Contaminant of Concern	**PRG for HI = 1.0 (mg/kg)**	**PRG for HI = 0.1 (mg/kg)**	**Site-Specific PRG for 5 µg/dL Blood-Lead Level[3] (mg/kg)**	**Site-Specific PRG for 8 µg/dL Blood-Lead Level[3] (mg/kg)**	**Site-Specific PRG for 10 µg/dL Blood Lead Level[3] (mg/kg)**	**Background UPL (mg/kg)**	**Maximum Concentration[2] (mg/kg)**
Worker							
Lead	NA	NA	500	800	1,000	9.19	20,800

1) Non carcinogenic hazard was below a level of 1, so noncancer endpoint is not evaluated.
2) Maximum concentration is for the entire Wilcox Oil Superfund Site.
3) PRGs for lead are rounded to one significant figure to remain consistent with EPA lead policy.
EPC - Exposure Point Concentration
mg/kg - milligrams per kilogram
NA - Not Applicable
HI - Hazard Index
PRG - Preliminary Remediation Goal
RME - Reasonable Maximum Exposure
UPL - Upper prediction limit

Attachment 1

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TABLE 1
PRG CALCULATION
REASONABLE MAXIMUM EXPOSURE
WILCOX OIL COMPANY SUPERFUND SITE - WILCOX PROCESS AREA
BRISTOW, CREEK COUNTY, OKLAHOMA

Location: Wilcox Process Area
Scenario Timeframe:
Current/Future Receptor
Population: Resident Receptor Age:

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Exposure Point Concentration	Carcinogenic Risk				Chemical of Concern	Non-Carcinogenic Hazard Quotient			
					Exposure Routes Total	Preliminary Remediation Goal				Primary Target Organ	Exposure Routes Total	Preliminary Remediation Goal	
						Risk = 10^{-6}	Risk = 10^{-5}	Risk = 10^{-4}				HI = 0.1	HI = 1.0
Soil	Surface Soil	Wilcox Process Area	**PAHs** BENZO(A)PYRENE	2.53	1.9E-05	NA	NA	NA	**PAHs** BENZO(A)PYRENE	Developmental System	NA	NA	NA
		Wilcox Process Area (Adult)	**PAHs** BENZO(A)PYRENE	2.53	2.7E-06	NA	NA	NA	**PAHs** BENZO(A)PYRENE	Developmental System	NA	NA	NA
		Wilcox Process Area (Adult + Child)	**PAHs** BENZO(A)PYRENE	2.53	2.2E-05	0.12	1.2	11.5					

TABLE 2

PRG CALCULATION
REASONABLE MAXIMUM EXPOSURE
WILCOX OIL COMPANY SUPERFUND SITE - WILCOX PROCESS AREA
BRISTOW, CREEK COUNTY, OKLAHOMA

Location: Wilcox Process Area
Scenario Timeframe: Current/Future
Receptor Population: Commercial/Industrial Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Exposure Point Concentration					Chemical of Concern	Non-Carcinogenic Hazard Quotient			
					Exposure Routes Total	Preliminary Remediation Goal				Primary Target Organ	Exposure Routes Total	Preliminary Remediation Goal	
						Risk = 10^{-6}	Risk = 10^{-5}	Risk = 10^{-4}				HI = 0.1	HI = 1.0
Soil	Surface Soil	Wilcox Process	**PAHs** BENZO(A)PYRENE	2.53	8.5E-07	3.0	30	299	**PAHs** BENZO(A)PYRENE	Developmental System	NA	NA	NA

Calculations of Preliminary Remediation Goals (PRGs) for Soil in Nonresidential Areas

U.S. EPA Technical Review Workgroup for Lead, Adult Lead Committee

Version date 06/14/2017 **EDIT RED CELLS**

Variable	Description of Variable	Units	GSDi and PbBo from Analysis of NHANES 2009-2014	GSDi and PbBo from Analysis of NHANES 2009-2014	GSDi and PbBo from Analysis of NHANES 2009-2014
$PbB_{fetal,\ 0.95}$	Target PbB in fetus (e.g., 2-8 µg/dL)	µg/dL	5	8	10
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	0.9	0.9	0.9
BKSF	Biokinetic Slope Factor	µg/dL per	0.4	0.4	0.4
GSD_i	Geometric standard deviation PbB	--	1.8	1.8	1.8
PbB_0	Baseline PbB	µg/dL	0.6	0.6	0.6
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	0.100	0.100	0.100
$AF_{S,\ D}$	Absorption fraction (same for soil and dust)	--	0.12	0.12	0.12
$EF_{S,\ D}$	Exposure frequency (same for soil and dust)	days/yr	250	250	250
$AT_{S,\ D}$	Averaging time (same for soil and dust)	days/yr	365	365	365
PRG in Soil for no more than 5% probability that fetal PbB exceeds target PbB		**ppm**	**460**	**846**	**1,103**